FINAL
TECHNICAL REPORT

EAGLE RIVER MEMORANDUM OF UNDERSTANDING PROJECT ALTERNATIVES STUDY – PHASE 2

Prepared for:
Aurora Water
Climax Molybdenum Company
Colorado River Water Conservation District
Colorado Springs Utilities
Eagle Park Reservoir Company
Eagle River Water and Sanitation District
Upper Eagle Regional Water Authority
Vail Associates, Inc.

Prepared by:
Wilson Water Group, LLC
Helton & Williamsen, P.C.
Leonard Rice Engineers, Inc.
RJH Consultants, Inc.
W.W. Wheeler & Associates, Inc.

November 29, 2016

Table of Contents

List of Tables

List of Figures

Section 1 Executive Summary

1.1 Purpose

The Eagle River Memorandum of Understanding (ERMOU) Project Alternatives Study Phase 2 (Study) provides evaluations of project alternatives to develop water storage and conveyance projects in the Eagle River basin for West Slope and East Slope interests. The purpose of this report is to present methodology and results of engineering, costing, water yield, and environmental evaluations associated with the Study.

1.2 Background and Objectives

The ERMOU contemplates development of a joint East Slope / West Slope water supply project to be located in the headwaters of the Eagle River watershed in Eagle County, Colorado. Cooperative partners and signatories to the ERMOU are the cities of Aurora and Colorado Springs, the Colorado River Water Conservation District, Climax Molybdenum Company, and the Vail Consortium comprised of Eagle River Water and Sanitation District, Upper Eagle Regional Water Authority, and Vail Associates (Partners). The ERMOU was executed in 1998.

The primary objectives of the ERMOU are as follows:

- <u>West Slope Water Users:</u> Develop a firm dry year yield of 10,000 acre-feet (ac-ft) per year.
- <u>Aurora and Colorado Springs:</u> Develop an average yield of 20,000 ac-ft per year.
- <u>Climax:</u> Develop an additional 3,000 ac-ft of water storage.

Numerous development alternatives for the ERMOU have been considered and evaluated by the Partners. These evaluations focused on individual projects at multiple locations in the Eagle River basin, but did not identify how project yields could be developed through a combination of projects. This Study was performed to evaluate combinations of water storage/conveyance projects in the Eagle River basin for the Partners, including two levels of evaluation as follows.

- **Tier 1 – Feasibility-Level Study:** Tier 1 evaluations were completed for three project alternatives (Eagle Park Reservoir, Whitney Creek Reservoir, and Bolts Lake) that were identified in Phase 1 of the Study as requiring additional feasibility-level study. These three alternatives are considered key facilities with good potential to contribute to ERMOU water yield objectives and that require refined information and decision processes for feasibility-level evaluation.

- **Tier 2 – Preliminary-Level Review:** Tier 2 evaluations were completed for four project alternatives (Wolcott Reservoir, Piney River Reservoir, Iron Mountain Reservoir, and Eagle-Arkansas Ditch) that were identified in Phase 1 of the Study as requiring additional preliminary-level review. These four alternatives require compilation of more preliminary information to assess their potential to contribute to ERMOU water yield objectives. The Wolcott Reservoir site is the only Tier 2 project alternative for which engineering, costing, water yield, and environmental evaluations were performed.

Following are descriptions of the three ERMOU Tier 1 project alternatives and the four ERMOU Tier 2 project alternatives, all located in Eagle County, Colorado. **Figure B-1** presents a site location map.

Eagle Park Reservoir

Eagle Park Reservoir is located near the western boundary of Climax Molybdenum Mine near Fremont Pass. The reservoir was formerly used by Climax as a tailings pond, and was later rehabilitated as a fresh water reservoir for augmentation, municipal, and instream uses by downstream entities including Vail Resorts, Eagle River Water and Sanitation District, the Upper Eagle Regional Water Authority, and the Colorado River Water Conservation District. The reservoir would be enlarged to store water from the East Fork Eagle River watershed for use by Climax and West Slope ERMOU Partners, or transferred to the Arkansas River basin for use by East Slope ERMOU Partners. This Study evaluated feasibility of an enlargement of the reservoir and added diversion and conveyance facilities to meet a portion of ERMOU yield objectives.

Whitney Creek Reservoir

The Whitney Creek Reservoir site would be located in the Homestake Creek valley downstream of the confluence with Whitney Creek. The new reservoir would be used to capture water from Homestake Creek and to store water diverted and conveyed from the Eagle River at Camp Hale and possibly from Fall Creek and Peterson Creek north of the Holy Cross Wilderness area. Project water stored in the reservoir would be transferred by pump to Homestake Reservoir for use by East Slope ERMOU Partners, or released to Homestake Creek for use by West Slope ERMOU Partners. This Study evaluated feasibility of various reservoir sizes and various diversion and conveyance facilities to meet a portion of ERMOU yield objectives.

Bolts Lake

Bolts Lake, located along the Eagle River just south of the town of Minturn, was constructed at the turn of the last century and historically used as a recreational fishing and boating pond. The dam was breached in 1997 and currently does not store water. Bolts Lake would be restored and used to store water from the Eagle River or Cross Creek that would be released for use by West Slope ERMOU Partners. This Study evaluated the feasibility of replacing the existing dam and developing new diversion and conveyance facilities to meet a portion of West Slope ERMOU yield objectives.

Wolcott Reservoir

The Wolcott Reservoir site would be located approximately one mile north of Interstate 70 near Wolcott, Colorado on Alkali Creek. The new reservoir would store water from Alkali Creek and the Eagle River and release it at Dowds Junction for West Slope uses. This Study evaluated feasibility of a reservoir and diversion and conveyance facilities to meet West Slope ERMOU yield objectives.

Piney River Reservoir

Piney River Reservoir was initially identified by Denver Water as part of their Eagle-Piney Eagle-Colorado project as a potential extension of its Roberts Tunnel Collection System. Subsequently, a smaller version of that concept was proposed to store water from the Piney River and its tributaries, deliver it to Red Sandstone Creek basin, and gravity flow to Gore Creek and the Eagle River. This Study provides a summary of key operational, hydrologic, and environmental components concerning preliminary feasibility as an ERMOU project.

Iron Mountain Reservoir

Iron Mountain Reservoir is the principal feature of the Red Cliff Project initially conceived as an on-channel reservoir on Homestake Creek. Homestake Creek yield to the reservoir was to be supplemented by supply from the Eagle River and Fall and Peterson Creeks. The project was also conceived to include hydropower infrastructure and operations. This Study provides a summary of existing information concerning preliminary feasibility as an ERMOU project.

Eagle-Arkansas Ditch

The Eagle-Arkansas Ditch is a concept that would divert water from the East Fork and South Fork Eagle River drainage basins and convey the water by gravity to the Arkansas River basin for use by East Slope interests. This Study provides a summary of existing information concerning preliminary feasibility as an ERMOU project.

1.3 Results and Conclusions

ERMOU projects and facilities identified in this Study would provide a wide range of feasible options to meet portions of ERMOU yield objectives. Following are results and conclusions associated with engineering and cost evaluations, water supply and project yield evaluations, and environmental evaluations.

Engineering and Costs

This Study includes feasibility-level engineering evaluations and new cost opinions for project components that had not been previously evaluated by others, as well as updated cost opinions for project components previously evaluated by others. Evaluations are consistent with a Class 5 level study as defined by the Association for the Advancement of Cost Engineering (AACE), which provides a level of project definition up to two percent, and a cost opinion reliability from minus 20–50 percent to plus 30–100 percent. Evaluations were performed using simplified engineering analyses with limited data and relied significantly on engineering judgement and experience with similar projects. Cost opinions were completed for various facility configurations associated with Eagle Park Reservoir, Whitney Creek Reservoir, Bolts Lake, and Wolcott Reservoir, as presented in **Table 1-1**. Detailed descriptions of these facilities are provided in **Section 0**.

Table 1-1. Opinion of Probable Construction Costs – ERMOU Project Alternatives

Component	Conveyance	Capacity	Average Pump Rate (ac-ft/yr)	Capital Cost ($M)	Fixed O&M Cost[4] ($M)	Variable O&M Cost[4] ($M)	Total Cost[5] ($M)
Eagle Park Reservoir							
Dam[1]	-	7,950 ac-ft	-	$ 68.4	$ 2.4	$ -	$ 70.8
Dam[2]	-	7,950 ac-ft	-	$ 37.8	$ 1.3	$ -	$ 39.1
Pipe/Pump	Eagle R blw Resolution Ck	40 cfs	8,000	$ 88.2	$ 12.0	$ 41.8	$ 142.0
Pipe/Pump	Eagle R blw Resolution Ck	40 cfs	5,000	$ 88.2	$ 12.0	$ 35.5	$ 135.7
Pipe/Pump	Eagle R blw Resolution Ck	150 cfs	8,000	$ 177.4	$ 28.1	$ 112.5	$ 318.0
Pipe/Pump	Eagle R blw Resolution Ck	150 cfs	5,000	$ 177.4	$ 28.1	$ 106.0	$ 311.5
Pipe/Pump	E Fk Eagle R blw Jones G	100 cfs	8,000	$ 93.0	$ 15.1	$ 68.6	$ 176.7
Pipe/Pump	E Fk Eagle R blw Jones G	100 cfs	5,000	$ 93.0	$ 15.1	$ 63.1	$ 171.2
Pipe/Pump	E Fork Eagle R (exist PS)	50 cfs	1,500	$ 30.1	$ 5.2	$ 8.5	$ 43.8
Pipe/Pump	Eagle Park Res to Chalk Ck	50 cfs	7,000	$ 37.0	$ 5.1	$ 21.7	$ 63.8
Pipe/Pump	Eagle Park Res to Chalk Ck	50 cfs	3,500	$ 37.0	$ 5.1	$ 18.2	$ 60.3
Whitney Creek Reservoir							
Dam-Alt 1	-	4,600 ac-ft	-	$ 67.9	$ 2.4	$ -	$ 70.3
Dam-Alt 2	-	6,850 ac-ft	-	$ 82.0	$ 2.9	$ -	$ 84.9
Dam-Alt 3	-	20,000 ac-ft	-	$ 106.8	$ 3.8	$ -	$ 110.6
Dam-Alt 4	-	1,000 ac-ft	-	$ 45.9	$ 1.6	$ -	$ 47.5
Pipe[3]	Eagle R blw Resolution Ck	200 cfs	-	$ 44.7	$ 2.7	$ -	$ 47.4
Tunnel	Eagle R blw Resolution Ck	200 cfs	-	$ 92.2	$ 2.8	$ -	$ 95.0
Tunnel	Fall/Peterson Creeks	200 cfs	-	$ 135.7	$ 4.8	$ -	$ 140.5
Pipe/Pump[3]	Whitney Ck Res to HS Res	200 cfs	20,000	$ 203.5	$ 21.7	$ 113.8	$ 339.0
Pipe/Pump[3]	Whitney Ck Res to HS Res	200 cfs	13,000	$ 203.5	$ 21.7	$ 103.7	$ 328.9
Bolts Lake							
Dam/Liner	-	1,200 ac-ft	-	$ 28.9	$ 1.0	$ -	$ 29.9
Pipe/Pump	Eagle R (Div Str No. 2)	50 cfs	600	$ 21.5	$ 5.0	$ 0.8	$ 27.3
Pipe/Pump	Eagle R (Div Str No. 3)	50 cfs	600	$ 17.7	$ 4.9	$ 1.1	$ 23.7
Wolcott Reservoir							
Dam	-	45,000 ac-ft	-	$ 216.0	$ 6.7	$ -	$ 222.7
Pipe/Pump	Eagle R nr Alkali Ck	150 cfs	13,000	$ 38.2	$ 9.0	$ 25.3	$ 72.5
Pipe/Pump	Eagle R nr Dowds Jct	175 cfs	13,000	$ 130.7	$ 8.4	$ 11.3	$ 150.4

1. Foundation seepage improvements below existing and new dam
2. Foundation seepage improvements below new dam only
3. Based on 54-inch diameter pipe
4. O&M costs represent present day costs based on 50-year life-span, 6.3 % interest rate, 3.8% inflation rate
5. Costs for property acquisition and easements are not included; costs for conveyance facilities are based on unit costs developed by Black and Veatch (2009), escalated to 2016 dollars

Water Supply and Project Yield

Water yield evaluations were completed for varied configurations (current and potential) of Eagle Park Reservoir, Whitney Creek Reservoir, Bolts Lake, and Wolcott Reservoir. Evaluations included analyses of the amount of water supply and project yield that could be available for each alternative (project scenarios) and for combinations of scenarios (project portfolios). Primary objectives of these evaluations were to estimate firm dry year yield for West Slope supply and average yield for East Slope supply through operation of the project alternatives and to develop preliminary capacity needs for project conveyance and storage facilities. Analysis was performed under the assumption that East Slope yields are unconstrained by East Slope infrastructure and operations and there is sufficient capacity in the East Slope delivery and storage systems to receive and fully utilize all water delivered by the ERMOU Project.

Water supply and project yield were evaluated with a daily simulation model of the Eagle River watershed that simulates project water conveyance and storage for the historical 1946 through 2014 period. Yield estimates for 13 ERMOU scenarios associated with Eagle Park Reservoir (5 scenarios), Whitney Creek Reservoir (6 scenarios), Bolts Lake (1 scenario), and Wolcott Reservoir (1 scenario) were combined with cost opinions described in the previous section, resulting in cost/yield estimates for each of the 13 scenarios. Descriptions of the scenarios are provided in **Table 1-2**. Cost/yield estimates for each of the scenarios are presented in **Table 1-3**. Specific scenarios associated with Eagle Park Reservoir (EP4 and EP5) and Whitney Creek Reservoir (WC1, WC2, WC3, and WC5) each include five cost/yield estimates to represent a range of yield ratios balanced between West Slope and East Slope uses. Water supply and project yield evaluations are presented in their entirety in **Section 4**.

Table 1-2. ERMOU Scenario Descriptions

Eagle Park Reservoir	
EP1	An enlarged Eagle Park Reservoir (**7,950 ac-ft**) would receive water from the existing pump station and pipeline (**6 cfs**) located on the East Fork Eagle River, and the system would be operated exclusively for West Slope purposes.
EP2	Same configuration as **Scenario EP1**, except the existing pump station and pipeline would be replaced with an enlarged conveyance system (**25-50 cfs**). The system would be operated exclusively for West Slope purposes.
EP3	An enlarged Eagle Park Reservoir (**7,950 ac-ft**) would receive water from a new pump station and pipeline (**40 cfs**) from the Eagle River below Resolution Creek, and the system would be operated exclusively for West Slope purposes.
EP4	An enlarged Eagle Park Reservoir (**7,950 ac-ft**) would receive water from a new pump station and pipeline (**100 cfs**) from the East Fork Eagle River below Jones Gulch, and water could be transferred from Eagle Park Reservoir to Chalk Creek in the Arkansas River basin with a new pump station and pipeline (**50 cfs**). The system would be operated for both West Slope and East Slope purposes.
EP5	An enlarged Eagle Park Reservoir (**7,950 ac-ft**) would receive water from a new pump station and pipeline (**150 cfs**) from the Eagle River below Resolution Creek, and water could be transferred from Eagle Park Reservoir to Chalk Creek in the Arkansas River basin with a new pump station and pipeline (**50 cfs**). The system would be operated for both West Slope and East Slope purposes.
Whitney Creek Reservoir	
WC1	This scenario represents a reservoir size where encroachment of the Holy Cross Wilderness area would not occur from either construction activities or reservoir inundation. A new Whitney Creek Reservoir (**4,600 ac-ft**) would receive water from Homestake Creek and from the Eagle River below Resolution Creek through a new tunnel (**200 cfs**), and water would be transferred from Whitney Creek Reservoir to Homestake Reservoir with a new pump station and pipeline (**200 cfs**). The system could be operated for both West Slope and East Slope purposes.
WC2	Same configuration as **Scenario WC1**, except with a reservoir size (**6,850 ac-ft**) where encroachment of the Holy Cross Wilderness area would not occur from construction activities, but may occur from reservoir inundation. The system could be operated for both West Slope and East Slope purposes.
WC3	Same configuration as **Scenario WC1**, except with a relatively large reservoir size (**20,000 ac-ft**) with associated construction activities and reservoir inundation that would not be constrained by the existing Holy Cross Wilderness area boundary (i.e. that a Wilderness boundary adjustment could be secured). The system could be operated for both West Slope and East Slope purposes.
WC4	Same configuration as **Scenario WC1** except with a relatively small off-channel reservoir with a size (**1,000 ac-ft**) and location intended to reduce environmental impact and not encroach on the Holy Cross Wilderness area. The system would be operated as a forebay exclusively for East Slope purposes to transfer water to Homestake Reservoir; water could be released from Homestake Reservoir for West Slope purposes.
WC5	Same configuration as **Scenario WC3** with added water supply through a new tunnel (**200 cfs**) from Fall and Peterson Creeks. The system could be operated for both West Slope and East Slope purposes.
WC6	Same configuration as **Scenario WC4** with added water supply through a new tunnel (**200 cfs**) from Fall and Peterson Creeks. The system would be operated as a forebay exclusively for East Slope purposes to transfer water to Homestake Reservoir; water could be released from Homestake Reservoir for West Slope purposes.
WC7	Same configuration as **Scenario WC1** with added water supply through a new tunnel (200 cfs) from Fall and Peterson Creeks. The system could be operated for both West Slope and East Slope purposes.
WC8	Same configuration as **Scenario WC2** with added water supply through a new tunnel (200 cfs) from Fall and Peterson Creeks. The system could be operated for both West Slope and East Slope purposes.
Bolts Lake	
BL1	An upgraded Bolts Lake (**1,200 ac-ft**) would receive water from a new pump station and pipeline (**50 cfs**) from the Eagle River, and the system would be operated exclusively for West Slope purposes.
Wolcott Reservoir	
WR1	A new Wolcott Reservoir (**45,000 ac-ft**) would receive water from a new pump station and pipeline (**175 cfs**) from the Eagle River at Dowds Junction, and the system would be operated exclusively for West Slope purposes.

Table 1-3. Cost/Yield Estimates – ERMOU Scenarios

Scenario	Water Source	Capacity (cfs)		Capital Cost[1] ($M)	New Storage (ac-ft)	New Annual Yield[2] (ac-ft)			Cost/Yield ($/ac-ft)
		From Source	To E. Slope			W.Slope Firm	E.Slope Average	Total	
Eagle Park Reservoir									
EP1	E Fk Eagle R	6	0	$ 70.8	4,650	1,500	0	1,500	$ 47,200
EP2		50	0	$ 114.6	4,650	1,750	0	1,750	$ 65,486
EP3	Eagle R blw Res Ck	40	0	$ 212.8	4,650	3,000	0	3,000	$ 70,933
EP4	E Fk Eagle R blw Jones G	100	50	$ 311.3	4,650	0	4,200	4,200	$ 74,119
						250	3,700	3,950	$ 78,810
						1,100	3,200	4,300	$ 72,395
						1,750	2,800	4,550	$ 68,418
						2,250	1,800	4,050	$ 76,864
EP5	Eagle R blw Resolution Ck	150	50	$ 452.6	4,650	0	10,700	10,700	$ 42,299
						500	9,400	9,900	$ 45,717
						1,500	7,900	9,400	$ 48,149
						2,250	6,400	8,650	$ 52,324
						3,000	4,500	7,500	$ 60,347
Whitney Creek Reservoir									
WC1	Eagle R blw Resolution Ck	200	200	$ 504.3	4,600	500	16,900	17,400	$ 28,983
						1,250	16,200	17,450	$ 28,900
						1,750	15,500	17,250	$ 29,235
						2,250	14,700	16,950	$ 29,752
						2,500	12,700	15,200	$ 33,178
WC2		200	200	$ 518.9	6,850	750	16,800	17,550	$ 29,567
						1,750	16,100	17,850	$ 29,070
						2,500	15,300	17,800	$ 29,152
						3,000	14,500	17,500	$ 29,651
						3,750	12,300	16,050	$ 32,330
WC3		200	200	$ 544.6	20,000	2,250	16,100	18,350	$ 29,678
						4,250	14,800	19,050	$ 28,588
						6,500	13,300	19,800	$ 27,505
						8,750	11,700	20,450	$ 26,631
						10,000	9,500	19,500	$ 27,928
WC4		200	200	$ 481.5	1,000	-	15,600	15,600	$ 30,865
WC5	Eagle R blw Resolution Ck + Fall/Peterson Creeks	200	200	$ 685.1	20,000	2,750	23,100	25,850	$ 26,503
						5,000	21,600	26,600	$ 25,756
						7,000	19,700	26,700	$ 25,659
						9,000	16,900	25,900	$ 26,452
						11,000	13,500	24,500	$ 27,963
WC6		200	200	$ 622.0	1,000	-	19,900	19,900	$ 31,256
WC7		200	200	$ 644.8	4,600	0	22,500	22,500	$ 28,658
						500	22,100	22,600	$ 28,531
						1,250	21,100	22,350	$ 28,850
						2,250	19,800	22,050	$ 29,243
						2,750	18,900	21,650	$ 29,783
						3,250	16,400	19,650	$ 32,814
WC8		200	200	$ 659.4	6,850	0	23,600	23,600	$ 27,941
						1,000	22,700	23,700	$ 27,823
						2,250	21,200	23,450	$ 28,119
						3,000	20,000	23,000	$ 28,670
						3,750	18,600	22,350	$ 29,503
						4,500	16,100	20,600	$ 32,010

Bolts Lake									
BL1	Eagle R Bolts	50	0	$ 57.2	1,200	1,000	0	1,000	$ 57,200
Wolcott Reservoir									
WR1	Eagle R Dowds	175	0	$ 373.1	45,000	21,000	0	21,000	$ 17,767

[1] Capital costs associated with Eagle Park Res include seepage improvements below existing dam and new dam, which could be substantially reduced if not required below existing dam. See Table 1-1 for further reference.

[2] Eagle Park Res yields do not include storage allocation for Climax or use of existing 3,300 ac-ft storage. W Slope firm yields would be reduced by approximately 500 ac-ft for every 1,500 ac-ft of Eagle Park Res storage allocated to Climax. Recent model simulations of existing Eagle Park Res system result in existing W Slope firm yield of 1,750 ac-ft, which may differ from previous estimates by others due to recent hydrology/model refinements. Total yield estimates may represent best case; actual future operational mitigation strategies may substantially reduce yield.

Yield and cost results presented in **Table 1-3** for Eagle Park Reservoir and for Whitney Creek Reservoir are shown graphically on **Figure 1-1** and **Figure 1-2**, respectively, which are intended to illustrate the potential balance between West Slope firm yield and East Slope average yield that may be obtained through alternative operational strategies.

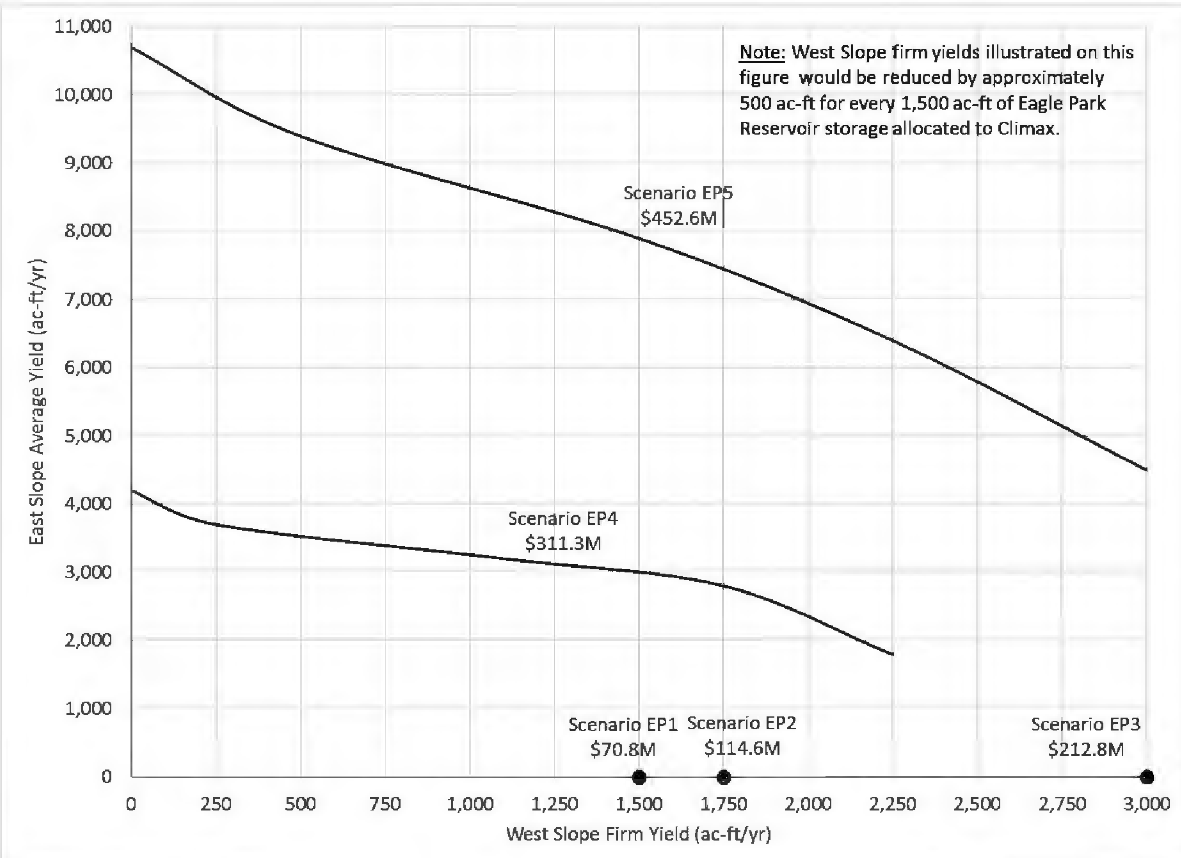

Figure 1-1. Yield Estimates – Eagle Park Reservoir Scenarios

As an example, illustrated on **Figure 1-1**, Scenario EP2 (enlarged 7,950 ac-ft reservoir and enlarged 50 cfs pump station with water supply from the East Fork Eagle River, costing an estimated $114.6 million) could attain up to 1,750 ac-ft/yr of new West Slope firm yield with no average yield allocated to the East Slope. Alternatively, as also illustrated on **Figure 1-1**, Scenario EP5 (enlarged 7,950 ac-ft reservoir and new 150 cfs pump station with water supply from the Eagle River below Resolution Creek, costing an estimated $452.6 million) could attain up to 3,000 ac-ft/yr of new West Slope firm yield combined with approximately 4,500 ac-ft/yr of new East Slope average yield.

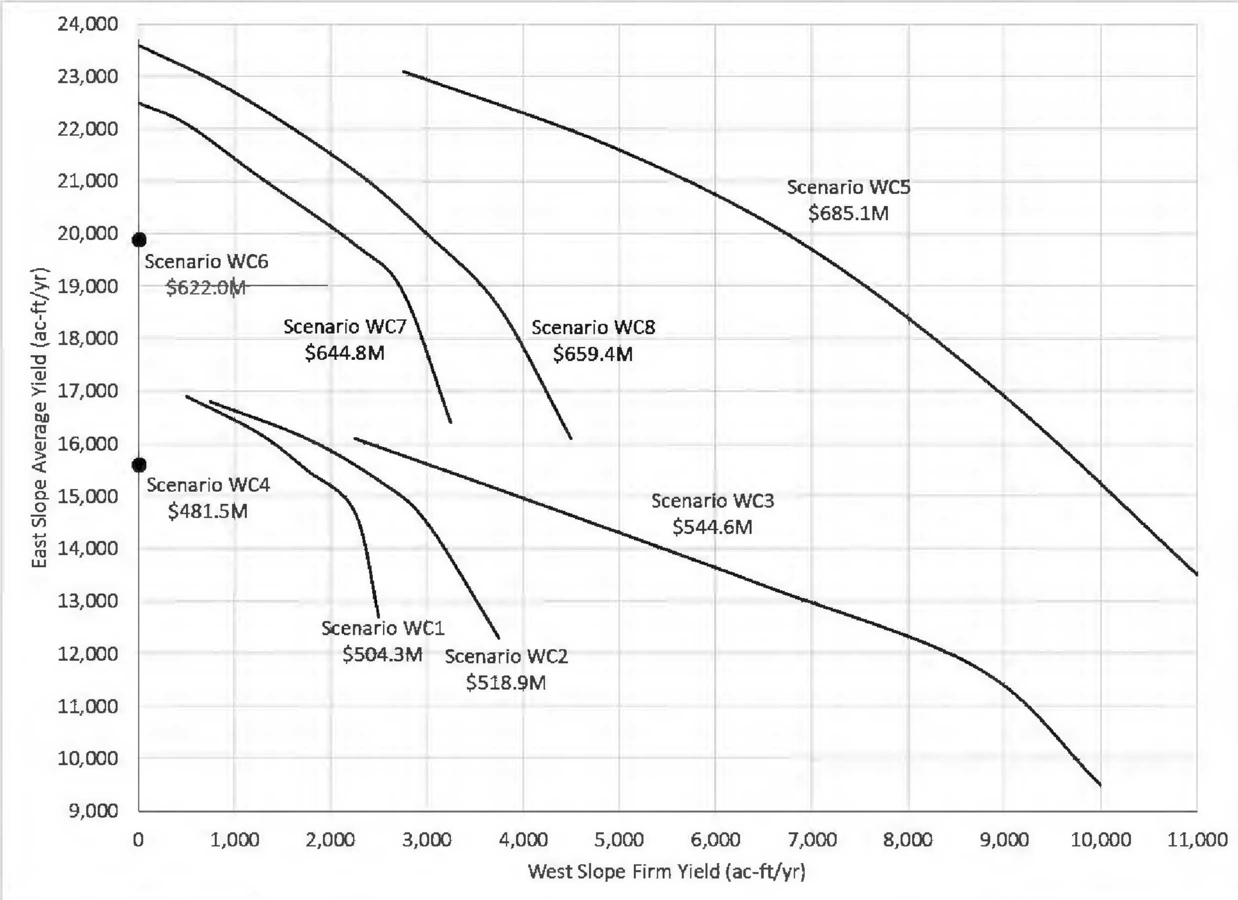

Figure 1-2. Yield Estimates – Whitney Creek Reservoir Scenarios

As an example illustrated on **Figure 1-2**, Scenario WC6 (relatively small off-channel forebay system with channel gravity-fed water supplies from Homestake Creek and tunnel gravity-fed water supplies from the Eagle River and Fall/Peterson Creeks, costing an estimated $622.0 million) could attain nearly 20,000 ac-ft/yr of East Slope average yield with no firm yield allocated to the West Slope. Alternatively, as also illustrated on **Figure 1-2**, Scenario WC5 (relatively large on-channel reservoir system with similar supplies as Scenario WC6, costing an estimated $685.1 million) could attain nearly 20,000 ac-ft/yr of East Slope average yield combined with approximately 7,000 ac-ft/yr of West Slope firm yield.

Information above presents cost/yield results for multiple variations of project scenarios to assess their potential to individually contribute to ERMOU objectives. This section presents cost/yield results for project portfolios to assess the potential for multiple scenarios to collectively contribute to ERMOU objectives. Twelve project portfolios, each with three variations of storage allocated to Climax, were evaluated with the same daily simulation model that was used to estimate yields for project scenarios in the previous section. Descriptions of the portfolios are provided in **Table 1-4**. Cost/yield estimates for each of the portfolios are presented in **Table 1-5**. Specific portfolios (3-6, 9, and 10) each include five cost/yield estimates to represent a range of yield ratios balanced between West Slope and East Slope uses. Model simulations indicate that West Slope firm yields presented in **Table 1-5** would be reduced by approximately 500 ac-ft for every 1,500 ac-ft of Eagle Park Reservoir storage allocated to Climax.

Table 1-4. ERMOU Portfolio Descriptions

Portfolios 1-6 include a common Eagle Park Reservoir configuration (**EP1**) with varying configurations of Whitney Creek Reservoir (**Scenarios WC4, WC6, WC1, WC2, WC3, and WC5**) to represent incrementally increasing levels of expected yield and incrementally increasing levels of expected environmental impacts associated with Whitney Creek Reservoir alternatives.
• **Portfolio 1** combines **Scenarios EP1 and WC4**. An enlarged Eagle Park Reservoir (**7,950 ac-ft**) would receive water from the existing pump station and pipeline (**6 cfs**) located on the East Fork Eagle River. A relatively small off-channel Whitney Creek Reservoir (**1,000 ac-ft**) would receive water from Homestake Creek, and from the Eagle River below Resolution Ck through a new tunnel (**200 cfs**), and water would be transferred from Whitney Creek Reservoir to Homestake Reservoir with a new pump station/pipeline (**200 cfs**).
• **Portfolio 2** combines **Scenarios EP1 and WC6** (same configuration as Portfolio 1 except the 1,000 ac-ft off-channel Whitney Creek Reservoir would also receive water from Fall and Peterson Creeks through a new tunnel of **200 cfs**).
• **Portfolio 3** combines **Scenarios EP1 and WC1** (same configuration as Portfolio 1 except Whitney Creek Reservoir would be **4,600 ac-ft**).
• **Portfolio 4** combines **Scenarios EP1 and WC2** (same configuration as Portfolio 1 except Whitney Creek Reservoir would be **6,850 ac-ft**).
• **Portfolio 5** combines **Scenarios EP1 and WC3** (same configuration as Portfolio 1 except Whitney Creek Reservoir would be **20,000 ac-ft**).
• **Portfolio 6** combines **Scenarios EP1 and WC5** (same configuration as Portfolio 5 except the 20,000 ac-ft Whitney Creek Reservoir would also receive water from Fall and Peterson Creeks through a new tunnel of **200 cfs**).
Portfolios 7-10 include a common Whitney Reservoir configuration (**WC6**) as Portfolio 2 (**1,000 ac-ft** off-channel Whitney Creek Reservoir with added water supply from Fall and Peterson Creeks) with varying configurations of Eagle Park Reservoir (**Scenarios EP2, EP3, EP4, and EP5**) to represent incrementally increasing levels of expected yield and incrementally increasing levels of expected environmental impacts associated with Eagle Park Reservoir alternatives.
• **Portfolio 7** combines **Scenarios EP2 and WC6** (same configuration as Portfolio 2, except the existing pump station and pipeline on the East Fork Eagle River would be replaced with an enlarged conveyance system of **25-50 cfs** to supply Eagle Park Reservoir).
• **Portfolio 8** combines **Scenarios EP3 and WC6** (same configuration as Portfolio 7, except the existing pump station and pipeline on the East Fork Eagle River would be replaced with a new pump station and pipeline of **40 cfs** from the Eagle River below Resolution Creek to supply Eagle Park Reservoir).
• **Portfolio 9** combines **Scenarios EP4 and WC6** (same configuration as Portfolio 7, except the existing pump station and pipeline on the East Fork Eagle River would be replaced with a new pump station and pipeline of **100 cfs** from the East Fork Eagle River below Jones Gulch to supply Eagle Park Reservoir, and water could be transferred from Eagle Park Reservoir to Chalk Creek in the Arkansas River basin with a new pump station and pipeline of **50 cfs**).
• **Portfolio 10** combines **Scenarios EP5 and WC6** (same configuration as Portfolio 7, except the existing pump station and pipeline on the East Fork Eagle River would be replaced with a new pump station and pipeline of **150 cfs** from the Eagle River below Resolution Creek to supply Eagle Park Reservoir, and water could be transferred from Eagle Park Reservoir to Chalk Creek in the Arkansas River basin with a new pump station and pipeline of **50 cfs**).
Portfolios 11 and 12 represent the same configurations as Portfolios 7 and 8, respectively, except each Portfolio would also include an upgraded Bolts Lake (**1,200 ac-ft**) that would receive water from a new pump station and pipeline (**50 cfs**) from the Eagle River.
• **Portfolio 11** combines **Scenarios EP2, WC6, and BL1**.
• **Portfolio 12** combines **Scenarios EP3, WC6, and BL1**.

[1] Each portfolio was evaluated with three variations of Eagle Park Reservoir storage capacity allocated to Climax:

- **Variation 1:** No storage allocated to Climax
- **Variation 2:** 1,500 ac-ft of storage allocated to Climax
- **Variation 3:** 3,000 ac-ft of storage allocated to Climax

Table 1-5. Cost/Yield Estimates – ERMOU Portfolios

Portfolio	Scenarios	Capital Cost ($M)[1]	New Storage (ac-ft)	New Annual Yield[2] (ac-ft/yr) W. Slope Firm	E. Slope Average	Total	Cost/Yield ($/ac-ft)
1	EP1+WC4	$552.3	5,650	1,550	13,000	14,550	$37,959
2	EP1+WC6	$692.8	5,650	1,550	17,200	18,750	$36,949
3	EP1+WC1	$575.1	9,250	2,050	16,200	18,250	$31,512
				2,800	15,500	18,300	$31,426
				3,250	14,900	18,150	$31,686
				3,550	14,400	17,950	$32,039
				4,050	12,300	16,350	$35,174
4	EP1+WC2	$589.7	11,500	2,250	16,100	18,350	$32,136
				3,250	15,400	18,650	$31,619
				4,050	14,700	18,750	$31,451
				4,550	14,000	18,550	$31,790
				5,250	11,800	17,050	$34,587
5	EP1+WC3	$615.4	24,650	3,750	15,300	19,050	$32,304
				5,800	14,100	19,900	$30,925
				8,050	12,600	20,650	$29,801
				10,250	11,000	21,250	$28,960
				12,050	8,800	20,850	$29,516
6	EP1+WC5	$755.9	24,650	4,300	22,500	26,800	$28,205
				6,550	20,900	27,450	$27,537
				8,550	19,300	27,850	$27,142
				10,550	16,600	27,150	$27,842
				12,550	13,200	25,750	$29,355
7	EP2+WC6	$736.6	5,650	1,750	19,600	21,350	$34,501
8	EP3+WC6	$834.8	5,650	3,000	18,200	21,200	$39,377
9	EP4+WC6	$933.3	5,650	0	22,400	22,400	$41,665
				250	22,000	22,250	$41,946
				1,000	21,500	22,500	$41,480
				1,750	21,000	22,750	$41,024
				2,250	20,200	22,450	$41,572
10	EP5+WC6	$1,074.6	5,650	0	23,900	23,900	$44,962
				500	22,800	23,300	$46,120
				1,500	21,600	23,100	$46,519
				2,250	20,700	22,950	$46,824
				3,000	20,000	23,000	$46,722
11	EP2+WC6+BL1	$793.8	6,850	2,750	19,500	22,250	$35,676
12	EP3+WC6+BL1	$892.0	6,850	4,000	18,200	22,200	$40,180

[1] Capital costs associated with Eagle Park Res include seepage improvements below existing dam and new dam, which could be substantially reduced if not required below existing dam. See Table 1-1 for further reference.

[2] Eagle Park Res yields do not include storage allocation for Climax or use of existing 3,300 ac-ft storage. W Slope firm yields would be reduced by approximately 500 ac-ft for every 1,500 ac-ft of Eagle Park Res storage allocated to Climax. Recent model simulations of existing Eagle Park Res system result in existing W Slope firm yield of 1,750 ac-ft, which may differ from previous estimates by others due to recent hydrology/model refinements. Total yield estimates may represent best case; actual future operational mitigation strategies may substantially reduce yield.

Yield and cost results presented in **Table 1-5** are shown graphically on **Figure 1-3**, which is intended to illustrate the potential balance between West Slope firm yield and East Slope average yield that may be obtained through alternative operational strategies. Model simulations indicate that West Slope firm yields presented on **Figure 1-3** would be reduced by approximately 500 ac-ft for every 1,500 ac-ft of Eagle Park Reservoir storage allocated to Climax.

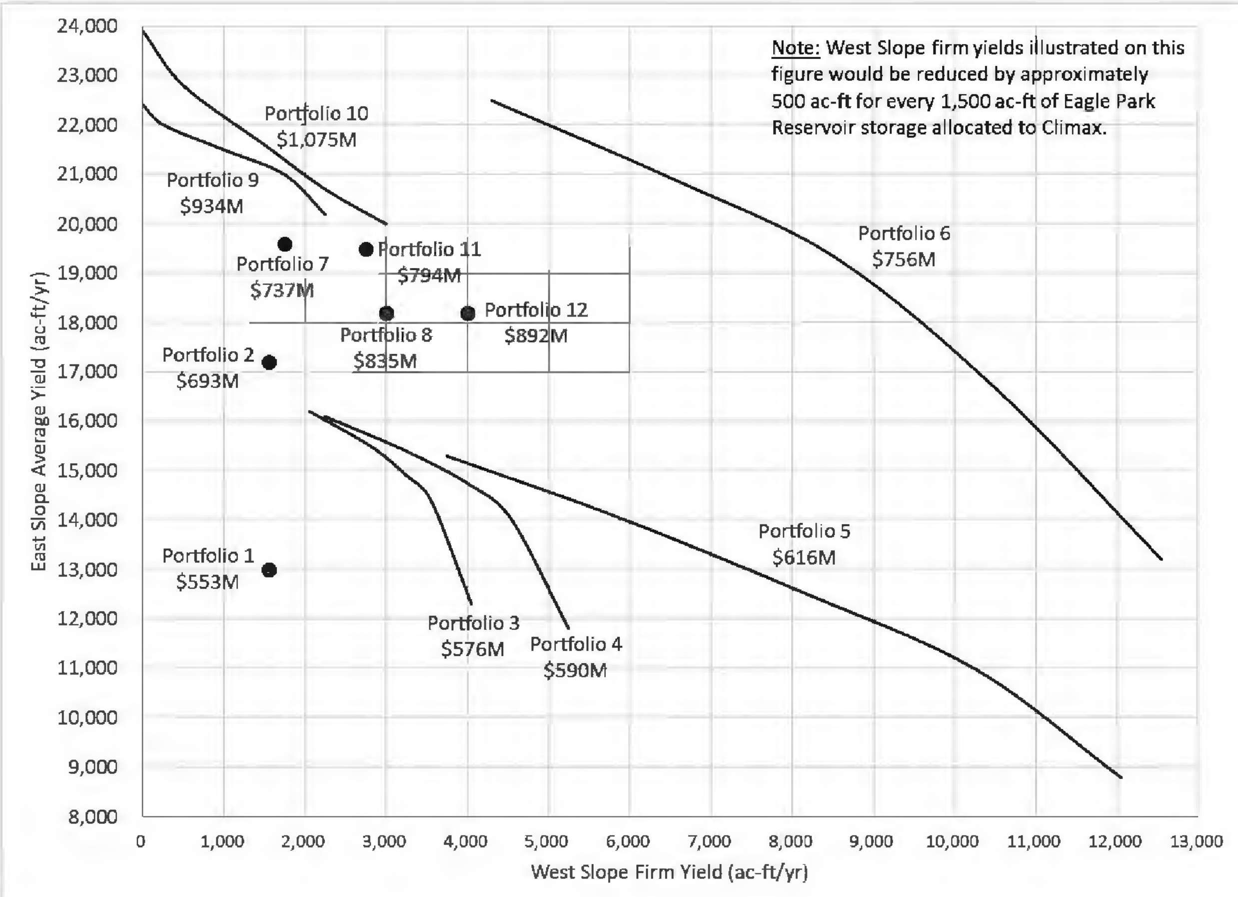

Figure 1-3. Yield Estimates – ERMOU Portfolios

As an example illustrated on **Figure 1-3**, Portfolio 1 (enlarged 7,950 ac-ft Eagle Park Reservoir and existing 6 cfs pump station with water supply from the East Fork Eagle River, combined with a relatively small off-channel Whitney Creek forebay system with channel gravity-fed water supplies from Homestake Creek and tunnel gravity-fed water supplies from the Eagle River, costing a combined estimated $553 million) could attain approximately 13,000 ac-ft/yr of East Slope average yield combined with approximately 1,500 ac-ft/yr of West Slope firm yield. Alternatively, as also illustrated on **Figure 1-3**, Portfolio 5 (the same Eagle Park Reservoir configuration as Portfolio 1, combined with a relatively large on-channel Whitney Creek Reservoir system with similar supplies as Portfolio 1, costing a combined estimated $616 million) could attain the same East Slope average yield as Portfolio 1 (approximately 13,000 ac-ft/yr) combined with approximately 7,000 ac-ft/yr of West Slope firm yield.

Environmental Requirements and Issues

Development of ERMOU facilities, including dams and reservoirs, pipelines, pump stations, and diversion facilities would require compliance with multiple federal, state, and local regulatory requirements. In most cases, the permitting requirements for the different options considered in the investigation will be nearly the same, but the environmental issues associated with individual facilities could be highly variable depending upon their specific locations and impacts. The major federal, state, and local permitting and approval requirements for the ERMOU project alternatives addressed in this Study are listed below. Detailed descriptions of these requirements are provided in **Section 5.1**.

- Federal Agencies
  - USDA Forest Service Special Use Permit and/or Rights-of-Way
  - U.S. Army Corps of Engineers – Section 404 Dredge and Fill Permit
  - U.S. Environmental Protection Agency – NEPA and 404 Permit Review
  - U.S. Fish and Wildlife Service – Endangered Species Act, Section 7 Consultation
  - U.S. Advisory Council on Historic Preservation – Cultural Resource Clearance
- State Agencies
  - Colorado Department of Public Health and Environment (CDPHE) – Water Quality Control Division – Clean Water Act, Section 401 Water Quality Certification
  - CDPHE – Air Pollution Control Division – Air Emissions Permit
  - Colorado Parks and Wildlife – referral agency for fish, wildlife, and recreation issues
  - Colorado Water Conservation Board – instream flow water rights issues
  - Colorado Department of Transportation – construction access and transportation issues
- Local Agencies
  - Eagle County – 1041 Land Use Permit
  - Town of Minturn – potential design review and grading/building permits

All Federal, State, and Local requirements summarized above would be applicable for Eagle Park Reservoir Enlargement, Whitney Creek Reservoir alternatives, Wolcott Reservoir, and likely Bolts Lake. For Bolts Lake, it is possible that U.S. Forest Service and Eagle County 1041 permitting would not be required if the reservoir and diversion from the Eagle River could be configured so that all project facilities are located on private lands within the Town of Minturn. For the larger capacity Whitney Creek Reservoir, congressional approval would be required to modify the boundary of the Holy Cross Wilderness Area.

Environmental permitting issues and mitigation requirements associated with Eagle Park Reservoir, Whitney Creek Reservoir, Bolts Lake, and Wolcott Reservoir were investigated based upon information readily available from resource databases and previous studies. This assessment of environmental permitting issues should be considered “preliminary” because site specific field investigations have not been conducted to verify the accuracy and completeness of the currently available information. **Table 1-6** provides a list of potentially significant environmental permitting issues identified for the ERMOU project alternatives. Additional details regarding these potential issues are provided in **Section 5.2**.

Table 1-6. Potential Environmental Issues – ERMOU Project Alternatives

Potential Issue[1]	Eagle Park Reservoir	Whitney Creek Reservoir	Bolts Lake	Wolcott Reservoir
Wetlands (potential impacted acres)	Up to 15	26–180	Up to 12	Up to 113
Wilderness and Roadless Areas	No	Yes[2]	No	No
USFS Forest Management Plan Amendments	Unlikely	Yes	No	No
Wildlife Habitat and Fisheries	Yes	Yes	Yes	Yes
Threatened and Endangered Species	Yes	Yes	Yes	Yes
Hydrology and Water Quality	Yes	Yes	Yes	Yes
Recreation	Unlikely	Yes	Unlikely	Unlikely

[1] Site specific investigations are required to fully understand the extent of potential impacts (adverse and beneficial) and to identify mitigation strategies, including possibilities for modifications of project facilities and operations to avoid and minimize adverse impacts.

[2] Potential Wilderness issues for two of four alternatives

1.4 Next Steps

The ERMOU Technical Advisors request ERMOU stakeholder review, comments, and discussion on the content and results of this Study and on the timing of and commitment to ERMOU project development. Should the ERMOU Partners elect to further evaluate specific project components presented in this report, the ERMOU Technical Advisors believe that collection of additional data and completion of additional evaluations, as summarized below, would significantly improve the reliability of the evaluations presented in this report. Next steps described below should be carefully coordinated between each technical discipline and with consideration for legal, economic, and institutional issues.

Engineering and Costs

Next steps for engineering and cost evaluations include obtaining additional data and performing more refined engineering analyses for preferred dam and reservoir facilities, identifying land ownership/ easement needs and corresponding potential acquisition costs, performing optimization of hydraulic conveyance facilities to better identify pump and pipeline sizes, and completing more detailed evaluations of pumping power needs for preferred ERMOU project alternatives. **High priority, near-term next steps include field geotechnical investigations associated with Whitney Creek Reservoir alternatives.** Additional detail on next steps are provided in **Section 6.1**.

Water Supply and Project Yield

Next steps for water supply and project yield evaluations include refined analyses to support and inform specific Partner objectives and next steps identified for the engineering and environmental disciplines. Corresponding evaluations would include added assessment of legal water availability and refined project water demands, operational constraints, and integration with existing water supply systems. **High priority, near-term next steps include determining how East Slope system constraints could impact East Slope yields and what additional infrastructure or operational changes are required to achieve full ERMOU yields.** Additional detail on next steps are provided in **Section 6.2**.

Environmental Requirements and Issues

Next steps for environmental evaluations include further site specific investigations to fully understand the extent of potential adverse and beneficial impacts and possibilities for modifications of project facilities and operations to avoid and minimize adverse impacts, and to identify mitigation strategies. **High priority, near-term next steps include continued coordination with USFS on the Camp Hale Wetland Reconstruction, Holy Cross Wilderness Boundary, and pending SF-299 permit application, including wetland investigations, environmental field surveys, and public outreach needed to proceed with subsurface explorations associated with the Whitney Creek Reservoir alternatives.** Additional detail on next steps are provided in **Section 6.3**.

Section 2 Introduction

2.1 Purpose

The Eagle River Memorandum of Understanding (ERMOU) Project Alternatives Study Phase 2 (Study) provides evaluations of multiple project alternatives to develop water storage and conveyance projects in the Eagle River basin for West Slope and East Slope interests. The purpose of this report is to present methodology and results of engineering, costing, water yield, and environmental evaluations associated with the Study.

2.2 Background and Objectives

The ERMOU contemplates development of a joint East Slope / West Slope water supply project to be located in the headwaters of the Eagle River watershed in Eagle County, Colorado. Cooperative partners and signatories to the ERMOU are the cities of Aurora and Colorado Springs, the Colorado River Water Conservation District, Climax Molybdenum Company, and the Vail Consortium comprised of Eagle River Water and Sanitation District, Upper Eagle Regional Water Authority, and Vail Associates (ERMOU Partners). The ERMOU was executed in 1998.

The primary objectives of the ERMOU are as follows:

- West Slope Water Users: Develop a firm dry year yield of 10,000 acre-feet (ac-ft) per year. Virtually all the consumptive portion of this supply is required at or downstream of the Eagle River at Dowds Junction, although some West Slope water is needed upstream of this location.
- Aurora and Colorado Springs: Develop an average yield of 20,000 ac-ft per year. It may be preferable to deliver East Slope water supplies to the existing Homestake Reservoir; however alternate delivery locations to the Arkansas or South Platte River watersheds may also be suitable.
- Climax: Develop an additional 3,000 ac-ft of water storage. Reservoir storage must be in a location in proximity to the Climax Mine site so that existing water supplies of Climax may be stored in the facility.

Numerous development alternatives for the ERMOU have been considered and evaluated by the Partners. These evaluations focused on individual projects at multiple locations in the Eagle River basin, but did not identify how project yields could be developed through a combination of projects. This Study was performed to evaluate combinations of water storage/conveyance projects in the Eagle River basin for the Partners, including two levels of evaluation as follows.

The ERMOU Partners held a planning workshop on December 8, 2014 where goals and objectives were reviewed and potential project development alternatives were discussed. During the workshop, Technical Advisors to the Partners were directed to review past investigations associated with project alternatives, and to develop a cooperative work plan to update the past investigations as appropriate. The Technical Advisors include Wilson Water Group (WWG), RJH Consultants (RJH), Helton & Williamsen (H&W), Leonard Rice Engineers (LRE), and W.W. Wheeler and Associates (WWW). The Technical

Advisors participated in a planning workshop on December 23, 2014 and developed a final draft work plan dated April 27, 2015. The final draft work plan was subsequently distributed to the Partners.

The ERMOU Partners directed the Technical Advisors to implement an initial screening of proposed project alternatives (Phase 1 Study) and identify specific project elements for feasibility-level evaluation in Phase 2. The Technical Advisors completed Phase 1 activities through compilation of supporting information (ERMOU Library), facilitation of a screening workshop on May 27, 2015, and documentation of a summary screening report dated July 8, 2015. The Phase 1 screening report recommends two levels of study for Phase 2:

Tier 1 – Feasibility-Level Study: Tier 1 evaluations were completed for three project alternatives (Eagle Park Reservoir, Whitney Creek Reservoir, and Bolts Lake) that were identified in Phase 1 of the Study as requiring additional feasibility-level study. These three alternatives are considered key facilities with good potential to contribute to ERMOU water yield objectives and that require refined information and decision processes. Work for each of the following technical disciplines was coordinated with the other technical disciplines to provide a basis for and review of each technical evaluation.

- Engineering evaluations included activities to identify project diversion, conveyance, and storage needs, capacities, and geotechnical issues. A primary objective of these evaluations was to develop or update construction cost estimates for key facilities.
- Water yield evaluations included investigations into the amount of water supply and project yield that could be available for each alternative (project scenarios) and for combinations of scenarios (project portfolios). A primary objective of these evaluations was to develop capacity needs for project conveyance and storage facilities.
- Environmental evaluations included determination of environmental permitting and approval requirements of federal, state and local agencies. A primary objective of these evaluations was to identify any environmental issues that could impact permitting processes and to identify potential mitigation requirements and opportunities.

Tier 2 – Preliminary-Level Review: Tier 2 evaluations were completed for four project alternatives (Wolcott Reservoir, Piney River Reservoir, Iron Mountain Reservoir, and Eagle-Arkansas Ditch) that were identified in Phase 1 of the Study as requiring additional preliminary-level review. These four alternatives require compilation of more preliminary information as listed below to assess their potential to contribute to ERMOU water yield objectives.

- Wolcott Reservoir – Engineering, costing, water yield, and environmental evaluations similar to Tier 1 evaluations and with a reduced level of detail
- Piney River Reservoir – Summary of key operational, hydrologic, and environmental components concerning preliminary feasibility as an ERMOU project
- Iron Mountain Reservoir – Summary of existing information concerning preliminary feasibility as an ERMOU project
- Eagle-Arkansas Ditch – Summary of existing information concerning preliminary feasibility as an ERMOU project

The Technical Advisors completed preliminary Phase 2 evaluations in January 2016. A coordination meeting was held on February 4, 2016 by the Technical Advisors to provide updates to the ERMOU Partners on progress made for Phase 2 of the project and to seek direction from the Partners on project reporting and next steps. This Phase 2 Study includes feasibility-level engineering, costing, water yield, and environmental evaluations, completed through a combined effort of the ERMOU Technical Advisors with a breakdown of responsibilities presented below.

- WWG – Project Management; Water Supply and Project Yield
- RJH – Engineering and Costing
- H&W – Water Supply and Project Yield
- LRE – Environmental Requirements and Issues
- WWW – Peer Review and Technical Support

Following are descriptions of the three ERMOU Tier 1 project alternatives and the four ERMOU Tier 2 project alternatives, all located in Eagle County, Colorado. **Figure B-1** presents a site location map.

Eagle Park Reservoir

Eagle Park Reservoir is located near the western boundary of Climax Molybdenum Mine near Fremont Pass at an elevation of 10,500 feet. The reservoir was formerly known as the Oxide Tailing Pond used by Climax, and in 1993, an agreement between Climax and Vail Associates was drafted to rehabilitate the tailings pond for use as a fresh water reservoir for downstream entities including Vail Resorts, Eagle River Water and Sanitation District, the Upper Eagle Regional Water Authority, and the Colorado River Water Conservation District. Reservoir rehabilitation was finished and Eagle Park Reservoir Company was formed in 1998. The reservoir serves as an important source of augmentation water for out-of-priority depletions for snowmaking and municipal uses, as well as releases for low-flow periods. In 2009, the reservoir was enlarged from 3,148 ac-ft to 3,301 ac-ft to increase storage needed to meet growing downstream demands and to better prepare for periods of drought.

Eagle Park Reservoir would be enlarged and used to capture runoff from its immediate watershed and to store water diverted and conveyed from the East Fork of the Eagle River. Project water captured by and conveyed to the reservoir would subsequently be released for use by West Slope ERMOU Partners or transferred by pump to Arkansas River basin for use by East Slope ERMOU Partners. This reservoir would also be used to store water for use by Climax. This Study evaluated feasibility of an enlargement of the reservoir and added diversion and conveyance facilities to supply water to the reservoir to meet a portion of ERMOU yield objectives.

Whitney Creek Reservoir

The Whitney Creek Reservoir site would be located in the Homestake Creek valley downstream of the confluence with Whitney Creek. The new reservoir would be used to capture water from Homestake Creek and to store water diverted and conveyed from the Eagle River at Camp Hale and possibly from Fall Creek and Peterson Creek north of the Holy Cross Wilderness area. Project water captured by and conveyed to the reservoir would subsequently be transferred by pump to Homestake Reservoir for use by East Slope ERMOU Partners, or released for use by West Slope ERMOU Partners. This Study evaluated feasibility of various reservoir sizes and various diversion and conveyance facilities to supply water to the reservoir to meet a portion of ERMOU yield objectives.

Bolts Lake

Bolts Lake is a 1,210 ac-ft reservoir located along the Eagle River just south of the town of Minturn. An earthen dam to impound the lake was constructed at the turn of the last century, and the lake was used for a period of time as a recreational fishing and boating pond. The lake is located just downstream of the Gilman mine, which was listed by the EPA in 1986 as a superfund site containing mine waste and then rehabilitated by the EPA and the State of Colorado in the early 1990s. In 1997, the State Engineer ordered that the earthen dam be breached so as to not impound water. Diversions from Cross Creek historically supplied water to the lake, and 2006 and 2007 decrees added the potential for water to be diverted from the Eagle River to the lake.

Bolts Lake would be lined, and the dam would be replaced and used to store water diverted and conveyed from the Eagle River. Project water conveyed to the lake would subsequently be released for use by West Slope ERMOU Partners. This Study evaluated feasibility of replacing the dam for lake storage and developing new diversion and conveyance facilities from the Eagle River to meet a portion of West Slope ERMOU yield objectives.

Wolcott Reservoir

The Wolcott Reservoir site would be located approximately one mile north of Interstate 70 near Wolcott, Colorado on Alkali Creek. Separate water rights associated with a Wolcott Reservoir concept are held both by the Colorado River Water Conservation District (Ute Creek concept) and Denver Water (Alkali Creek concept). Potential issues have been identified with storage development at the Ute Creek site, such as a local landfill that could impact water quality and limit reservoir capacity and dam borrow materials. This Study evaluated feasibility of one reservoir size at the Alkali site and diversion and conveyance facilities to supply water to the reservoir to meet West Slope ERMOU yield objectives.

The new reservoir would store water diverted from Alkali Creek and the Eagle River either via a pump station immediately below the reservoir, or via a gravity pipeline up valley from Dowds Junction. Stored water would subsequently be pumped from the reservoir through the same pipeline used to fill the reservoir and released to the Eagle River at Dowds Junction for West Slope uses.

Piney River Reservoir

Piney River Reservoir was initially identified by Denver Water as part of their Eagle-Piney/Eagle-Colorado Project as a regulating reservoir for water pumped from Eagle-Colorado Reservoir (aka Wolcott Reservoir). A smaller version of that concept was proposed by Brown and Caldwell to store water from the Piney River, deliver it to Red Sandstone Creek basin, and gravity flow to Gore Creek and the Eagle River. This Study provides a summary of key operational, hydrologic, and environmental components concerning preliminary feasibility as an ERMOU project.

Iron Mountain Reservoir

Iron Mountain Reservoir is the principal feature of the Red Cliff Project initially conceived in the 1950s as an on-channel reservoir on Homestake Creek with a decreed capacity of over 68,000 ac-ft. Homestake Creek yield to the reservoir was to be supplemented by supply from the Eagle River (via the Pando Feeder Canal) and Fall and Peterson Creeks (via pipelines), for a combined annual project yield of 26,000 ac-ft. The project was also conceived to include hydropower infrastructure and operations (Gilman Power Conduit). This Study provides a summary of existing information concerning preliminary feasibility as an ERMOU project.

Eagle-Arkansas Ditch

The Eagle-Arkansas Ditch is a concept that would divert water from four tributaries in the East Fork Eagle River drainage basin (Cataract Creek, Sheep Gulch, Jones Gulch, and East Fork Eagle River) and from three tributaries in the South Fork Eagle River drainage basin (Fiddler Creek, Taylor Creek, and Piney Creek) and convey the water by gravity over Tennessee Pass to the Arkansas River basin for use by East Slope ERMOU Partners. Conveyance facilities would include a new common gravity pipeline connecting the seven tributaries to an existing abandoned railroad tunnel under Tennessee Pass. The common pipeline would parallel existing access roads along the East Fork Eagle River and south of Camp Hale and then along Highway 24 to the Tennessee Pass tunnel. This Study provides a summary of existing information concerning preliminary feasibility as an ERMOU project.

Section 3 Evaluations – Engineering and Costs

3.1 Evaluation Approach

Engineering Approach

Engineering and cost evaluations were completed by RJH with technical input and peer review by WWG and WWW. Work was coordinated with other technical disciplines to provide a basis for and review of engineering and cost evaluations.

Numerous engineering evaluations have been performed by various consultants at the ERMOU project sites over the last 30 years. Some of the evaluations were performed directly for the collective ERMOU Partners, while others were performed for individual ERMOU Partners or for other entities such as private developers. These evaluations varied from project to project and ranged from screening-level evaluations to 30-percent designs. The ERMOU Partners directed the ERMOU Technical Advisors to maximize use of these existing engineering evaluations for this Phase 2 Study, in conjunction with performing new engineering evaluations for project components that had been previously evaluated. Previous investigations and evaluations performed by others were reviewed for each of the ERMOU project sites to identify technical issues that could impact feasibility-level design concepts and cost opinions. **Section 7** presents a summary of previous studies reviewed to support engineering and cost evaluations. A site location map of the ERMOU facilities is presented on **Figure A-1**.

Feasibility-level engineering evaluations were performed for project components that had not been previously evaluated. The level of effort for the feasibility-level evaluations varied from site to site depending upon available data and the extent of previous evaluations, but in general, the feasibility-level engineering evaluations and cost opinions were consistent with about a Class 5 level study as defined by the Association for the Advancement of Cost Engineering (AACE). This provides a level of project definition up to about 2 percent. The feasibility-level evaluations were performed using simplified engineering analyses with limited data and relied significantly on engineering judgement and experience with similar projects. The general objectives for the feasibility-level engineering evaluations include:

- Developing approximate sizes and general locations for facilities.
- Identifying potential fatal flaws.
- Identifying additional data needed to advance project work.
- Providing a basis for developing feasibility-level cost opinions.

Cost Estimating Approach

Capital Costs

The primary intent of the cost opinions is to provide relative cost comparisons between various project alternatives and sites. It is the opinion of ERMOU Technical Advisors that the cost opinions are not appropriate for developing project budgets. In general, new cost opinions were developed for project components evaluated in this Study, whereas cost opinions for project components previously

evaluated by other consultants were updated as part of this Study. The approach for developing new cost opinions and updating previous cost opinions varied by type of facility.

Ideally, the cost opinions would have been developed for project components that were defined using a similar level of analysis because this would have provided more reliable cost comparisons between the project alternatives and sites. However, the ERMOU Partners decided that for this phase of project development, previous work, concepts, and costs that were developed by other consultants should be used whenever possible. The ERMOU Technical Advisors endeavored to use consistent unit costs between the project alternatives and sites to improve the comparative reliability. It is the opinion of the ERMOU Technical Advisors that the comparative costs in this report should not be used as the primary factor in eliminating a site or for selecting a site to advance into the next stage of design without additional analysis.

As previously discussed, ERMOU Phase 2 engineering evaluations are consistent with about a Class 5 level study as defined by the AACE. Based on guidance provided by AACE for Class 5 estimates, the overall reliability of the cost opinions is estimated to be between about minus 20 to 50 percent on the low side, and plus 30 to 100 percent on the high side.

The cost opinions are based on professional opinions and will likely change as more data is collected and design details are developed. Also, actual costs would be affected by several factors beyond current control such as supply and demand for the types of construction required at the time of bidding, changes in material supplier costs, changes in labor rates, competitiveness of contractors and suppliers, availability of qualified bidding contractors, changes in applicable regulatory requirements, changes in design standards, and other factors. Conditions and factors arising as the Project proceeds from development through bidding and construction may result in construction costs that differ significantly from the cost opinions provided in this Report.

Dams and Reservoirs

Cost opinions for dam and reservoir facilities (i.e. Eagle Park Reservoir and Whitney Creek Reservoir) were developed by estimating quantities of primary elements of the work based on the feasibility-level design concepts and unit costs developed from the following sources:

- Published and non-published bid price data for similar work.
- R.S. Means Heavy Construction Cost Data for 2015.
- Manufacturer's budgetary price quotes.
- Previous experience and judgment.

In general, cost opinions for dam and reservoir facilities evaluated by other consultants (i.e. Bolts Lake and Wolcott Reservoir) were updated by applying historical construction cost index values from Engineering News Record (ENR) to update the cost opinions to 2016 dollars. In several isolated instances, to provide a more consistent cost comparison between the various facilities, unit costs developed as part of ERMOU engineering evaluations were used to update cost opinions developed by other consultants for select bid items.

Conveyance Facilities

Cost opinions for evaluated conveyance facilities were developed based on unit cost and lump sum cost information presented in the Camp Hale to Eagle Park Reservoir Water Delivery System Report by Black and Veatch (2009). Unit costs and lump sum costs were updated to 2016 dollars using historical construction cost index data from ENR. It is the opinion of the ERMOU Technical Advisors that using cost information presented in 2009 Black and Veatch report as the basis for developing new cost opinions is appropriate for the following reasons:

- This approach will provide a more consistent cost comparison between various conveyance facilities alternatives.
- The level of effort for the Black and Veatch report is consistent with about a 30-percent design, which is significantly more detailed than the work performed as part of this Study. The Black and Veatch report includes a relatively detailed cost breakdown.
- The Black and Veatch report includes many of the same components for conveyance facilities as those being evaluated including diversion structures, pump stations, pipelines, electrical lines, electrical substations, etc.
- Manufacturers were contacted for key cost items including vertical turbine pumps and steel pipe and confirmed that the unit cost and lump sum costs presented in the Black and Veatch report are reasonable.

Unit and lump sum costs from the 2009 Black and Veatch report were also applied to conveyance facilities evaluated by others to provide a more consistent cost comparison for all the conveyance facilities.

Allowances

The "Base Construction Subtotal" (BCS) for each Project component is the sum of construction costs for primary work elements. This includes materials, equipment, labor and subcontractors. Allowances are then added to the BCS to account for direct costs not included in the BCS such as mobilization, bonds, and insurance; and indirect costs such as design and construction contingencies, construction engineering, and permitting. Allowances are used to provide an overall cost estimate required to construct the project and to account for uncertainties associated with BCS.

Allowances were developed based on guidance from AACE and experience with similar projects. The OPCC is the sum of the BCS and the following allowances:

- 5 percent of the BCS for the construction contractor's costs for mobilization and demobilization, bonds, and insurance.
- 30 percent of the BCS for contingencies to account for uncertainties regarding the design and construction.
- 10 percent of BCS for construction engineering and management.
- 8 percent of BCS for design engineering.
- 5 percent of BCS for permitting.

Operations and Maintenance Costs

An opinion of probable fixed and variable operations and maintenance (O&M) costs was developed. Fixed O&M costs are anticipated to include routine maintenance and non-variable operations costs. Annual fixed O&M costs were estimated as a percentage of the BCS for each facility. Fixed O&M costs will vary by type of facility and will be higher for facilities with mechanical and electrical equipment (i.e. pump stations) and facilities that may collect sediment and debris (i.e. diversion structures). Annual fixed O&M costs were estimated based on engineering experience and judgment. Annual fixed O&M costs as a percentage of the BCS are presented in **Table 3-1**.

Table 3-1. Annual Fixed O&M Costs as a Percentage of BCS

Component	Percent of BCS
Diversion Structures	4.0%
Pipelines	0.2%
Tunnels	0.1%
Dams	0.2%
Pump Stations	1.5%

Variable O&M costs would consist primarily of pumping costs, which would vary depending on the volume of water being pumped. Annual power costs were estimated for each pump station based on flow rate, pumping head, an assumed pump efficiency of 80 percent, and an annual volume of water being pumped. A power cost of $0.034/kW-hour and a demand charge of $10/kW/month was used based on information provided by Xcel Energy, who it is understood would be the likely energy provider. It may be possible to negotiate a better rate or the ERMOU Partners may also have more reliable rate information that could be used. Power costs for pumping are expected to be the primary component of variable O&M costs, which in turn, are expected to greatly influence viability of ERMOU project alternatives. Recommendations are provided in Section 6 to perform more detailed evaluations of pumping power needs for preferred ERMOU project alternatives.

Annual O&M costs were converted to present day costs considering a) 50 years of operation and b) an average interest rate of 6.3% and an average inflation rate of 3.8%. The interest rate represents an average of 10-year and 20-year municipal bond rates over the last 40 years based on data from the Federal Reserve. The inflation rate is the average inflation rate in the United States over the last 40 years based on data from the Federal Reserve. Additional information for the cost opinions is presented in **Section 3.3**.

3.2 Project Evaluations

3.2.1 Eagle Park Reservoir

3.2.1.1 Existing Facilities

The existing storage and conveyance facilities include a dam and reservoir, and a 6 cfs pump station with pipeline located about 2,000 feet downstream of the dam. The pump station and pipe enable water to be pumped from the East Fork Eagle River to Eagle Park Reservoir.

The existing dam is 135-feet high with a storage capacity of about 3,301 acre-feet. The dam is currently classified as a large, high-hazard dam. The dam consists of an inclined clay core with rockfill shells.

The dam was originally designed and approved to be constructed in three stages. The first stage of the dam was constructed in 1964 at a height of 105 feet with a crest at El. 10,705. The second and third stages of dam construction were designed to include downstream embankment raises to El. 10,745.0 and El. 10,790.0, respectively; however, the second stage was only partially completed and the third stage was never completed. The existing dam was constructed about halfway between the first and second stage and has a crest at El. 10,725.0. The reservoir was used as a mining tailings pond from 1964 until 1998 (Black and Veatch, 2009). The existing reservoir was created by excavating tailings and remediating the existing embankment.

A spillway was constructed in 1998 and consists of a 50-foot wide trapezoidal concrete control structure located along the left abutment of the dam. The spillway is used to control the maximum normal operating pool of the reservoir. The spillway originally had a crest elevation of El. 10,717.5. The spillway crest was raised in 2008 to El. 10,720.0.

A mid-level outlet works was constructed in 1998 near the right abutment of the dam. The mid-level outlet works consists of 24-inch diameter reinforced concrete pipe (RCP) with a reinforced concrete, sloping intake structure. Flows through the mid-level outlet works are controlled by a manually actuated slide gate with an invert at El. 10,684.75. Two 60 horsepower (Hp) submersible pumps with a combined capacity of 10 cfs are located at elevation 10,632 feet. The pumps discharge through the trash rack into the mid-level outlet works. Approximately 143 ac-ft of dead storage is located below the intakes for the submersible pumps. The mid-level outlet works discharges to a 75-foot long segment of open channel and then to a 400-foot long, 30-inch diameter high-density polyethylene (HDPE) pipeline that extends near the right groin of the dam. The HDPE pipe discharges to a reinforced concrete baffle outlet structure near the toe of the dam.

Water in the reservoir is not considered contaminated, but seepage that passes through the existing rockfill embankment collects tailings residue and is considered by regulatory agencies to be contaminated (Black and Veatch, 2009). Seepage collects in a small pond near the toe of the dam, and seepage collected in the pond is pumped into Robinson Lake. A pump station is located at the west side of the pond. The pump station includes two 75 horsepower (Hp) in-line pumps with a total pumping capacity of 585 to 680 gallons per minute (gpm). Flows are pumped from the pond through a 4,900-foot long, 8-inch diameter HDPE pipe to Robinson Lake. Based on information provided by Climax, seepage

rates have been on the order of 15 gallons per minute. A barrier wall is located just downstream of the pond to reduce the amount of seepage that enters the local groundwater.

Seepage collection facilities are also located at the downstream toe of Robinson Lake. Seepage collection facilities at Robinson Lake include a pump station, collection pond, cutoff wall, return pipeline, and water quality monitoring well.

The existing East Fork Eagle River Pump Station was constructed in 2007 and includes a diversion structure, a 6 cfs pump station, and discharge pipeline. The diversion structure is located on the East Fork Eagle River near the pump station and consists of a reinforced concrete weir structure. Flow from the East Fork Eagle River is conveyed by gravity through a 20-inch diameter HDPE pipeline from the diversion structure to the pump station. The pump station consists of a pre-fabricated metal building with a reinforced concrete, trench-type wet well. Three vertical turbine pumps are located in the pump station: two 1,150 gpm (2.56 cfs) pumps and one 400 gpm (0.89 cfs) pump. A 2,900-foot long, 14-inch diameter HDPE discharge pipe extends from the pump station to Eagle Park Reservoir. The pipeline discharges to the reservoir near the left abutment at El. 10,721.5.

3.2.1.2 Evaluations

Modifications at the Eagle Park Reservoir site would consist of the following components:

- Enlarging the existing dam to provide increased reservoir storage.
- Constructing conveyance facilities to fill the reservoir from one of the following downstream diversion locations:
    - Eagle River near Camp Hale
    - East Fork Eagle River near Jones Gulch
    - East Fork Eagle River at the existing 6 cfs pump station
- Constructing conveyance facilities to convey water from Eagle Park Reservoir to Chalk Creek on the eastern side of the Continental Divide.

A general plan of facilities for the Eagle Park Reservoir site is presented on **Figure A-2**.

Cost opinions associated with the following facilities are presented in **Section 3.3**.

3.2.1.2.1 Dam and Reservoir

Enlargement of Eagle Park Reservoir would generally include the following components:

- Demolishing the existing spillway and abandoning the existing mid-level outlet works pipe.
- Constructing a rockfill and earthfill downstream embankment raise.
- Constructing a spillway in bedrock along the right abutment.
- Installing a new outlet works near the maximum section of the dam to accommodate releases of the entire reservoir.
- Relocating seepage collection facilities currently located at the downstream toe of the dam.

All the property required to construct the enlargement is owned by Climax. A general plan of modifications to the dam and ancillary facilities is presented on **Figure A-3**. A description of relevant components and construction considerations is presented below.

Reservoir

The maximum size of the reservoir is limited by the existing seepage collection facilities at the downstream toe of Robinson Lake. Based on discussions with the ERMOU Partners, it is understood that these facilities should not be inundated by the normal operating pool or flood pool of an enlarged Eagle Park Reservoir. Therefore, the flood pool should not be higher than about El. 10,784.0 to prevent inundation of the Robinson Lake seepage collection facilities. Based on this flood pool, a maximum normal pool at El. 10,775.0 and a dam crest at El. 10,785.0 was selected, which would provide 9 feet of flood routing head and 10 feet of total freeboard. The reservoir storage at El. 10,775.0 is approximately 7,950 ac-ft, which would be an increase of 4,650 ac-ft from the existing reservoir. Enlarging the dam to El. 10,785.0 would increase the dam height to 195 feet. The dam would remain a large, high-hazard dam. It is possible that the flood pool elevation could be lowered by increasing the spillway width. Further optimization of the pool levels and spillway width should be evaluated in future stages of design.

The enlarged reservoir normal pool would be about 11 feet above the bottom of the barrier wall of the Robinson Lake seepage collection facilities, which is at about El. 10,764.0. The reservoir pool may need to be lowered if there is a need to modify the barrier wall or perform underground repairs. An existing water quality monitoring well downstream of the barrier wall would be inundated by the reservoir and would need to be relocated. Evaluating modifications to the existing seepage collection facilities at Robinson Lake was not included in this evaluation but should be evaluated in future stages of design.

An elevation-capacity relationship for an enlarged reservoir was developed based on a) information from the 2006 spillway modification construction drawings (Brown and Caldwell) for storage below the existing dam crest and b) topography developed from the 2-meter DEM (Sky Research 2009) for storage above the existing dam crest. The elevation-capacity information is presented in **Appendix A**.

Embankment Modifications

Both an upstream and downstream embankment raise concept were initially considered. However, an upstream raise concept was subsequently dismissed because the internal zoning of the existing embankment is configured for a downstream raise and connecting to this zoning with an upstream raise would not be feasible. It is the opinion of the ERMOU Technical Advisors that a feasible and practical option for the downstream raise would be a combination earthfill and rockfill embankment with the core geometry from the existing embankment generally being maintained. The primary disadvantage with a downstream raise is that the existing seepage collection facilities would need to be relocated. Advantages of a downstream raise include:

- Reduces the amount of time the reservoir needs to be drained.
- Eliminates storage losses that would be caused by an upstream raise.
- Reduces the susceptibility of core cracking by maintaining the existing core geometry.

- Facilitates installation of a filter/drain to manage seepage through the embankment.

The core and upstream shell would consist of earthfill and the downstream shell would consist of rockfill. A filter layer and transitions zones would be installed between the rockfill and the core or existing downstream shell. Riprap slope protection would be installed on the upstream slope to protect against wave erosion. A downstream raise would require demolishing the existing spillway along the right abutment and mid-level outlet works near the left abutment, and relocating the existing seepage collection facilities located near the downstream toe. A typical maximum section for a downstream raise of the embankment and a typical section near an abutment are shown on **Figure A-4**.

A significant uncertainty associated with enlarging the dam is managing seepage beneath the existing dam. Based on the 1964 construction drawings (Meuer, Serafini, and Meurer), the seepage management facilities at the existing embankment consist of a core trench with a minimum width of 20 feet that extends 3 feet below the top of bedrock. It is understood that there is not a grout curtain beneath the existing dam. Based on seepage data provided by Climax, it is understood that measured seepage rates are typically about 15 gpm. This is a relatively low seepage rate for a dam with this amount of hydraulic head, but seepage rates could increase significantly if the reservoir pool is increased by 55 feet. It is possible that an enlarged embankment would require seepage management improvements below the existing dam.

The ERMOU Technical Advisors currently do not have sufficient data to evaluate if the foundation and embankment core would provide suitable seepage management for the raised embankment. It is possible that the existing foundation and embankment would provide suitable seepage management for the raised embankment because a) the embankment has been performing satisfactorily, b) historic seepage rates have been relatively low, and c) the embankment was originally designed for a higher raise than what is being proposed. However, the embankment was originally designed as a tailings dam and may not have been designed to acceptable or current standards for a permanent water retention facility. Also, limited data is available regarding the material composition and properties of the existing core and the foundation.

For this planning Study, cost opinions were developed for enlarging the dam with and without foundation and embankment seepage barrier improvements in and below the existing embankment. The foundation and existing embankment could be improved either individually or in combination. Foundation improvements would likely consist of removing a portion of the existing embankment crest to create a working platform and installing a grout curtain through the existing core trench prior to placing fill for the embankment raise. The embankment improvements would likely consist of removing a portion of the existing embankment crest to create a working platform and constructing a barrier wall to the top of bedrock prior to placing fill for the embankment raise. The new core material for the embankment raise would be connected to the top of the barrier wall. The need for these improvements could be better evaluated if subsurface explorations were performed to evaluate the properties of the existing core and foundation.

Spillway

Raising the embankment would require constructing a new spillway along the right abutment. There was initial consideration for constructing the spillway along the left abutment, but the topography is too steep to accommodate a reasonable excavation. Simplified reservoir routing analyses were performed, and a 120-foot wide spillway with a broad crested weir was identified to be required to route the inflow design flood (IDF) with 9 feet routing head. This would result in a peak outflow of about 8,200 cfs. This spillway size is significantly larger than the existing spillway, which was approved by the SEO. However, information on the hydrologic analyses used to size the existing spillway was not provided; and therefore, conservative hydrologic analyses were performed, resulting in the larger spillway. It is likely that the spillway size could be reduced by more refined hydrologic analyses in the next stage of design.

The spillway would consist of a concrete control weir at El. 10,775.0 with an excavated, unlined channel in bedrock along the right abutment. Excavation would likely require blasting, and excavated material would likely be suitable for rockfill. The spillway would discharge to a small drainageway that eventually discharges to East Fork Eagle River about 3,500 feet downstream of the dam. Spillway flows would discharge uncontrolled over the existing access road. It may be desirable to install a box culvert and line the overlying road segment with concrete to protect the road during more frequent (i.e. lower) flood events. The road would likely experience significant damage during the IDF event and be unusable.

Outlet Works

The existing reservoir contains approximately 143 ac-ft of dead storage. A low-level outlet works would be constructed near the maximum section of the dam to accommodate releases of the entire reservoir and obviate the need for the two existing submersible pumps. The outlet works would consist of a low-level, reinforced concrete intake structure near the upstream toe of the dam with a hydraulically actuated slide gate; a 30-inch diameter steel pipe encased in concrete; and a reinforced concrete, USBR-type baffled outlet structure near the downstream toe for energy dissipation. The pipe size was selected to provide a hydraulic capacity of 50 cfs, which is the largest recorded native inflow. This pipe size would allow the top 5 feet of the reservoir to be released in less than 5 days, as required by the SEO for a high hazard dam.

Construction of the low-level outlet works would require excavating a portion of the existing embankment. It is estimated that about 3,200 cy of existing embankment material would need to be excavated. This material would be stockpiled and used to reconstruct the existing embankment. Excavating a portion of the existing embankment would require draining the reservoir. It is likely that the excavation, outlet works construction, and existing embankment reconstruction could be performed in one construction season. If draining the reservoir is not feasible, the outlet works could tunnel through the left abutment. This would require tunneling through rock, constructing a vertical shaft tower, and installing a low-level intake structure and intake pipeline using divers to accommodate a "live tap" installation. This option would cost significantly more than installing the outlet works by excavating the existing embankment. The cost opinion was developed based on an outlet works installed by excavation.

If water quality issues are a concern, an intake tower could be constructed instead of a low-level intake structure. An intake tower would be as high as the raised embankment and would accommodate selective withdrawals at various reservoir elevations. A bridge would need to be provided to access the top of the tower. An intake tower would cost significantly more than a low-level intake structure. The cost opinion was developed based on a low-level intake structure.

Seepage Collection Facilities

The existing seepage collection facilities would need to be relocated downstream of the modified dam embankment. The relocated seepage collection facilities would be located at the downstream toe near the existing discharge channel. Seepage rates could increase significantly if the reservoir pool is increased by 55 feet, but the existing pumps have a combined capacity of about 585 to 680 gpm, which in the opinion of the ERMOU Technical Advisors, should provide significant additional capacity to accommodate increases in seepage rates above the existing approximate 15 gpm seepage. For this reason, it is anticipated that the existing pumps and pump building could be reused. Relocation of the seepage collection facilities would involve constructing a new collection pond, concrete foundation, and barrier wall; and reinstalling the pumps and pump building. Approximately 3,100 feet of the existing 8-inch diameter HDPE return pipe would be covered by the enlarged embankment and reservoir pool and would need to be relocated along the toe and south abutment of the dam. Relocating the return pipeline through this area may be challenging because of the steep, rocky terrain. Blasting or rock excavation is expected to be required to create a bench for installing the pipeline. Alternatively, the return pipeline could be routed around the north edge of the reservoir, which has less challenging terrain, but this would increase the pipeline length to about 7,200 feet. Alternatives for the return pipeline route should be evaluated in the future stages of design.

Access Roads

The existing access road located along the south edge of the reservoir would be inundated by the enlarged reservoir pool and would need to be abandoned. Constructing a new access road along the new south edge of the reservoir would be challenging because of the steep, rocky terrain. For this feasibility-level Study, it was considered that all access to the dam and ancillary facilities would be from the existing access road along the north edge of the reservoir. A bridge crossing over the new spillway would be required if the ERMOU Partners desire to use the road during flood events. The possibility of constructing an access road along the south edge of the enlarged reservoir should be further evaluated in the future stages of design.

Borrow Areas

The enlarged embankment will require a significant quantity of rock fill, granular fill, and core materials (i.e. clayey materials). A cursory evaluation of potential borrow material locations was performed based on previous engineering studies and regional geology maps. A site map of potential borrow areas is presented on **Figure A-5**. A summary of potential borrow locations and materials is as follows.

- Area 1 – Area located in the upstream portion of the Eagle Park Reservoir. Material in this area includes till that appears to overlay limestone beds and igneous intrusions. These materials could possibly be used for rock fill and granular fill materials. However, there may be an insufficient quantity of available granular materials in this area to construct all the dam modifications.
- Area 2 – Area located immediately south of Eagle Park Reservoir. Material in this area includes primarily igneous intrusions and limestone beds, which may be durable enough to produce rock fill.
- Area 3 – Area located southwest of Robinson Lake. Material in this area may potentially be used for granular fill materials. 17 test pits were previously performed throughout Area 3 (and a portion of Area 2) to investigate the large till deposit. Test pits encountered 5 to 15 feet of sand and gravel with cobbles overlying siltstone or igneous bedrock.
- Area 4 – Area located east of the Robinson Tailings Pond. Material in this area consists of landslide deposits that include a matrix of sand, silt, and clay, which may potentially be used for granular fill and core materials. Material in this area could be heterogeneous and may contain considerable boulders; processing may be required to obtain suitable core material.
- Area 5 – Area located east of the Mayflower Tailings Pond. Material in this area consists of till with possible clayey matrix, which may potentially be used for core materials. Material in this area could be heterogeneous and may contain considerable boulders; processing may be required to obtain suitable core material.
- Area 6 – Area located at the existing Climax mine site. Based on information from Climax, it is understood that this area may be a good source of clayey materials, especially in the Mosquito fault gouge mined from the Climax pit. It is understood that this material would be run-of-the mine material and could be stockpiled during ongoing mining activities for future use at the dam.

Climax has stated that Areas 2 and 3 should be considered separate from “affected lands” as defined under the Climax DRMS permit. A new borrow area outside of the existing permitted area has the potential to be pulled into the affected land status if its disturbance is viewed as related to the mining operation and this would trigger a reclamation permit amendment. Borrow area applications would not be related to mining operations but steps should be taken to ensure a reclamation permit amendment is not required.

It is understood that Areas 4 and 5 may not be available because Climax is currently planning to use materials in this area for reclamation of Tailings Storage Facilities. Also, these areas are highly visible from the highway and there may be potential utility conflicts.

A key challenge will be obtaining a sufficient supply of core materials from nearby locations. If core materials cannot be obtained from nearby locations, then it may be possible to process Pierre Shale materials located within the region. Based on a cursory review of geology maps, Pierre Shale is exposed regionally in the following locations:

- North of Wolcott
- Blue River Valley between Dillon and Kremmling
- South Platte River Valley between Como and Hartsel

Efforts associated with processing and hauling costs to transport these materials to the site would be significant. Another option could be amending on-site soils with imported bentonite to produce a low-permeable material. It is anticipated that about 3 to 6 percent bentonite would be required to produce low-permeable fill suitable for use as core material. Bentonite would be blended into the site soil using discs and other processing equipment. The amended soil would be moisture conditioned, placed, and compacted using conventional earthfill construction techniques.

The cost estimate was based on obtaining core materials from one of the local borrow areas (Areas 4, 5, or 6).

3.2.1.2.2 Conveyance Facilities

Conveyance facilities were evaluated to provide design concepts similar to those presented in the 2009 Black and Veatch report. Significant components such as pump types and sizes, pipeline type and alignment, itemized components, etc. from the Black and Veatch report were utilized for project efficiency and to provide consistent cost estimates. Conveyance facilities were sized for estimated peak flow rates. The conveyance facilities generally include the following project components:

- <u>Diversion Structures</u> – Diversion structures would be required for conveyance facilities that would be used to fill the reservoir. The diversion structures are anticipated to consist of a reinforced concrete intake structure immediately upstream of a reinforced concrete diversion dam with an Obermeyer gate. Obermeyer gates are hydraulically operated inflatable bladders with steel panels that can be raised or lowered to select operating points. A gravity pipe would extend from the intake structure to the wet well of a pump station.
- <u>Pump Stations</u> – Pump stations are anticipated to consist of below-grade reinforced concrete wet wells or above-grade steel tank wet wells, above-grade concrete masonry unit buildings, and constant speed vertical turbine pumps with associated control equipment include control valves, surge tanks, process piping, etc. The pumps would be selected to provide a firm capacity so that one pump could be out of service and the peak flow could still be achieved. The potential benefit of using variable speed pumps was not considered at this stage of project development.
- <u>Pipelines</u> – Pipelines are anticipated to consist of cement mortar-lined steel pipe with external tape wrap. Steel pipe with butt welds would be used for high pressure applications and lap welded steel pipe would be used for lower pressure applications. Rock excavation would likely be required for areas above Camp Hale. Through Camp Hale, excavations are anticipated to be primarily in sediment, sand, and gravel materials. Pipelines were generally sized to limit headloss to 3 feet per 1,000 feet of pipeline and velocities to less than 8 feet per second.

- Power Supply – Based on the 2009 Black and Veatch report, it is understood that there is an existing 115 kV overhead power line owned by Xcel Energy near the site but it would be more cost effective to construct a new 115/12 kV substation. The substations would be owned and operated by Xcel and would include a transformer, switchgears, a control building, and separate circuit breakers serving each pump station. 3 phase, 12 kV distribution cables would extend from the substation to each pump station.

Significant optimization of these project components would be required in future stages of design. Specifically, the size of the pipelines and the number of pump stations are interrelated and several different combinations should be evaluated to identify economic and technical advantages and disadvantages.

Eagle River near Camp Hale to Eagle Park Reservoir

Facilities to convey water from the Eagle River near Camp Hale to Eagle Park Reservoir were evaluated by Black and Veatch in the 2009 report for both 40 cfs and 150 cfs systems. Flows would be diverted from the Eagle River just downstream of its confluence with Resolution Creek. The location of the diversion structure would need to be coordinated with the restoration work occurring at Camp Hale. The pipeline alignment generally follows the alignment of the existing access road. It is understood that there are existing unexploded ordnances (UXO) in the Camp Hale area that would need to be identified and properly removed. A plan and hydraulic schematic profile of the conveyance facilities for the 40 cfs and 150 cfs systems are presented on **Figures A-6 and A-7**, respectively. Additional information is presented in the 2009 Black and Veatch report.

The 40 cfs system would include a diversion structure; 7.4 miles of 36-inch diameter steel pipe; a 7,500 Hp pump station; a 6,250 Hp pump station; an electrical substation; and electrical distribution cables.

The 150 cfs system would include a diversion structure; 7.4 miles of 60-inch diameter steel pipe; three 18,000 Hp pump stations; a 115/12 kV electrical substation, and electrical distribution cables.

E. Fork Eagle River near Jones Gulch to Eagle Park Reservoir

Facilities to convey water from the East Fork Eagle River near Jones Gulch to Eagle Park Reservoir were evaluated for a peak flow rate of 100 cfs. The pipeline alignment would generally follow the alignment of the existing access road. The 100 cfs system would include a diversion structure; 4 miles of 48-inch diameter steel pipe; two 14,000 Hp pump stations; a 115/12 kV electrical substation; and electrical distribution cables. A plan and hydraulic schematic profile of the conveyance facilities is presented on **Figure A-8**.

E. Fork Eagle River Pump Station to Eagle Park Reservoir

Facilities to convey water from near the existing pump station at East Fork Eagle River to Eagle Park Reservoir were evaluated for a peak flow rate of 50 cfs. An initial evaluation was performed to determine if modifications could be performed to the existing 6 cfs pump station to increase its capacity to 50 cfs. However, the wet well and pump building are too small to accommodate an 800-percent increase in pumping capacity. The existing pump station and pipeline could be left in place and a 44 cfs

pump station and pipeline could be constructed to operate in parallel with the 6 cfs system; or the 6 cfs pump station could be abandoned or demolished and a new 50 cfs pump station and pipeline could be constructed. There may be some cost savings with preserving the existing 6 cfs pump station, but this would also require maintenance and operation of two separate facilities.

Evaluations were performed for a new 50 cfs diversion structure, pump station and pipeline. These components could be constructed on Climax property. The 50 cfs system would include a diversion structure; 0.6 miles of 36-inch diameter steel pipe; one 5,000 Hp pump station; a 115/12 kV electrical substation; and electrical distribution cables. The new pipeline would extend along the toe of the dam and would likely need to be encased in concrete or in a carrier pipe to meet SEO requirements. A plan and hydraulic schematic profile of the conveyance facilities is presented on **Figure A-9**.

Eagle Park Reservoir to Chalk Creek

Facilities to convey water from Eagle Park Reservoir to Chalk Creek were evaluated for a peak flow rate of 50 cfs. A pump station would be located near the toe of Eagle Park Reservoir dam. The dam outlet works would include a bifurcation with a pipe extending to the pump station. The pipeline alignment would extend through Climax property to the east side of the Continental Divide. The downstream 4,000 feet of the pipeline would not be located on Climax property. It may be possible to maintain the entire pipe alignment on Climax property but this would require discharging to Chalk Lake. It is unknown if Chalk Lake and its downstream drainage have sufficient capacity to convey flows up to 50 cfs.

The 50 cfs system would include a 7,500 Hp pump station; 2.6 miles of 36-inch diameter steel pipe; and a 115/12 kV electrical substation. A plan and hydraulic schematic profile of the conveyance facilities is presented on **Figure A-10**.

3.2.2 Whitney Creek Reservoir

3.2.2.1 Existing Facilities

There are no existing hydraulic facilities located at the Whitney Creek Reservoir site. Homestake Road (FSR 703) extends along the bottom of the valley near Homestake Creek to Homestake Reservoir. The USFS Holy Cross Wilderness Area is along the north side of the valley and a USFS Roadless Area is along the south side of the valley. Motorized vehicles are prohibited in the Wilderness and Roadless Areas.

The USFS Gold Park Campground is located along Homestake Creek, and based on discussions with the USFS, it is understood that this campground and nearby trails receive significant use. Homestake Road is the only route to the Gold Park Campground. Homestake Road is also used to access Homestake Reservoir by maintenance personnel.

UXOs have historically been identified within the Homestake Creek valley as a result of military training exercises previously conducted at Camp Hale. It is understood that the US Army Corps of Engineers previously completed a surface clearance of the site. 75-mm and small arms ordnance were identified and removed.

3.2.2.2 Evaluations

Work at the Whitney Creek Reservoir site would consist of the following components:

- Constructing a new dam on Homestake Creek downstream of Whitney Creek or constructing a new off-channel dam.
- Constructing conveyance facilities to fill the reservoir from one of the following diversion locations:
  - Eagle River near Camp Hale (pipeline or tunnel).
  - Fall Creek and Peterson Creek (tunnel).
- Constructing conveyance facilities to convey water from Whitney Creek Reservoir to Homestake Reservoir.
- Relocating a portion of Homestake Road around the reservoir

A general plan of facilities for the Whitney Creek Reservoir site is presented on **Figure A-11**.

Cost opinions associated with the following facilities are presented in **Section 3.3**.

3.2.2.2.1 Dam and Reservoir

Based on discussions with the ERMOU Partners and Technical Advisors, feasibility-level evaluations were performed for four reservoir alternatives. Alternatives 1 through 3 would include dams constructed across Homestake Creek, and Alternative 4 would be an off-channel reservoir (i.e. no dam across Homestake Creek). The three on-channel alternatives include:

- Alternative 1 – This alternative would avoid both inundation from the maximum normal reservoir pool and construction activities in the Wilderness Area.
- Alternative 2 – This alternative would allow inundation from the maximum normal reservoir pool but avoid construction activities in the Wilderness Area.
- Alternative 3 – This alternative would provide 20,000 ac-ft of reservoir storage. Inundation from the maximum reservoir pool and construction activities would occur in the Wilderness Area.

Construction of an on-channel dam would generally include construction of an embankment on Homestake Creek, rock cut spillway along the right abutment, outlet works, and realignment of Homestake Reservoir Road.

There was initial consideration for both preferred sites (Sites 2 and 3) presented in the 2014 Grand River Consulting and RJH report. Both sites appear to be generally geologically similar and technically feasible. Site 2 was selected for this Study, but both sites should be considered for future stages of project development. The centerline alignments of the embankments vary to accommodate rock-cut spillways through the right abutment, but are in the general vicinity of Site 2 (i.e. within about 500 feet).

Alternative 4 would provide a storage capacity of 1,000 ac-ft. An off-channel reservoir has some significant advantages compared to a traditional, on-channel reservoir including:

- Homestake Road would not need to be relocated.
- The spillway and outlet works could be significant smaller.
- Significantly fewer wetlands would be impacted.
- Could be located to not impact the Wilderness Area.

The off-channel reservoir would include an embankment, rock cut spillway, and outlet works located about 2,500 feet northeast of Site 2 at the downstream end of a small drainage. A portion of the dam and reservoir would be located on private property. A siting study was not performed for the off-channel reservoir, and other potential off-channel sites may have more advantages. Also, other types of facilities, such as an excavated reservoir with liner, were not considered.

All the reservoir alternatives would accommodate gravity flow from the Eagle River near Camp Hale. The diversion on the Eagle River would be about El. 9,200.0. The pipeline to Whitney Creek Reservoir was selected by Black and Veatch to maintain headlosses below 50 feet. Therefore, the maximum water surface elevation for Whitney Creek Reservoir alternatives is 9,150.0.

An overall plan of the dams and reservoirs is presented on **Figure A-12**. Plans of the dams and ancillary facilities for Alternatives 1, 2, 3, and 4 are presented on **Figures A-13**, **A-14**, **A-15**, and **A-16**, respectively. A description of relevant components and construction considerations is presented below.

Reservoir

Elevation-capacity relationships were developed for each alternative using the 2-meter DEM (Sky Research 2009). A summary of dam crest elevations, maximum normal pool elevations and corresponding storage volumes is presented in **Table 3-2**. Elevation-capacity information is presented in in **Appendix A**.

Table 3-2. Reservoir Characteristics – Whitney Creek Reservoir Alternatives

Component	Maximum Normal Pool Elev.	IDF Pool Elev.	Dam Crest Elev.	Approx. Storage Capacity at Max. Normal Water Elev.
Alt 1	9,040.0	9,054.0	9,055.0	4,600
Alt 2	9,065.0	9,079.0	9,080.0	6,850
Alt 3	9,112.0	9,126.0	9,127.0	20,000
Alt 4	8,990.0	8,994.0	8,995.0	1,000

Embankment – Alternatives 1 to 3

Based on a 2015 geologic evaluation, the site appears suitable to support a dam. Geologic hazards include multiple shear zones that cross the site, slope instability along the valley walls, seismicity, and foundation seepage potential from fractured and weathered bedrock. These geologic hazards are typical of high mountain terrain, and, based on current data, do not present technical fatal flaws.

The embankment alternatives were developed for a concrete face rockfill dam (CFRD). A CFRD would be a feasible and economic concept for the embankment because there appears to be a sufficient supply of hard rock materials nearby. The primary disadvantage of a CFRD is settlement of the rockfill may require maintenance of the concrete facing. It is anticipated that a sufficient supply of rock and concrete aggregate could be obtained from the reservoir basin and spillway excavation. An asphalt core rockfill dam may also be a feasible concept, but not many asphalt core rockfill dams have been constructed in the United States. The ERMOU Technical Advisors did not want to base a feasibility-level evaluation on a relatively uncommon technology in the United States. A traditional earthen embankment or earth core rockfill dam may not be practical or economical because of a lack of cohesive soils near the site. A roller compacted concrete (RCC) dam was also considered. An RCC dam is expected to be more expensive than a CFRD because of the width of the valley. An RCC dam could accommodate an overtopping spillway. However, because most of the rock excavation for the spillway could be used as rockfill in the CFRD, the cost of the spillway is not significant.

The CFRD would consist of a mass placement of 12 to 24 inch rockfill with concrete facing located along the upstream slope. Transition zones of smaller rockfill would be located between the concrete facing and the larger rockfill for seepage management. The concrete facing would prevent uncontrolled seepage through the rockfill and allow water to be retained in the reservoir. The rockfill embankment would extend to an adequate foundation, which was considered to be weathered bedrock at an average depth of about 30 feet below the bottom of the valley. The existing glacial material on the bottom of the valley would be removed. Except below the plinth, it is not anticipated that special treatment of the bedrock surface would be required if the existing glacial material is removed. A typical embankment section is presented on **Figure A-17**.

Seepage control would consist of installing a concrete plinth with rock anchors and a triple-row grout curtain at the upstream toe. Highly weathered/fractured bedrock at the plinth foundation may need to be removed to expose competent rock that would provide an adequate foundation. Some shaping of the rock surface may also be required to eliminate irregularities and produce a relatively even surface that would not produce stress concentrations below the plinth. The rock anchors would be used to help maintain a tight bond and anchor the plinth concrete to the underlying foundation rock.

The embankment will require a significant quantity of rock fill materials and concrete aggregate. Based on previous geologic evaluations of the site, the bedrock materials generally consist of migmatite, which would be appropriate to use for rock fill materials. The cost estimate was developed based on a borrow source in the reservoir basin and spillway area, which is anticipated to be feasible.